Art. XXVII.—*Machine-Drawn versus Hand-Drawn Milk: An Enquiry into the Relative Bacterial Content.*

By NORMAN MacDONALD, B.V.Sc.

(Government Research Scholar in the University of Melbourne).

[Read 14th December, 1911.]

In Australia perhaps even more than most other parts of the world, the provision of some mechanical means whereby the drudgery of milking cows by hand can be at least reduced to a minimum, if not entirely obviated, is by many considered a necessity if the dairying industry is to develop to its full extent.

Year by year dairymen are finding it more difficult to secure the necessary labour for the milking of cows, chiefly because it is work that permits of few or no holidays, and because it is work that, although not onerous, is very exacting.

It is many years since the first mechanical apparatus was devised for milking of cows, but it is only within the past decade that any of these has proved even a comparative success. That such milking machines are growing in favour year by year is evident to anyone who cares to keep in touch with dairying interests, but in the opinion of many the use of such machines is deleterious to the cow's udder, and to the purity of the milk supply. On the other hand it is held by many intelligent farmers who have had experience of the machines that the modern forms of the apparatus more closely simulate the action of the calf's mouth and tongue than does the human hand, and that provided the machine is properly attended to, especially as regards cleanliness, the mammary gland is not affected, and the possibility of bacterial contamination of the milk is greatly minimised.

In view of these opposing contentions, both of which are to be found supported by very definite statements, and in the absence of comparative records of the two processes being carried out under satisfactory and uniform conditions, it

seemed highly advisable, especially as it is obvious that a satisfactory machine would prove of great value to the industry, that some scientific investigation should be made.

The opportunity for such an investigation presented itself last summer. The Lady Talbot Milk Institute, a charitable organisation instituted for the special purpose of providing infants with a pure milk supply from healthy, tuberculin tested cows, has for the past two or three years secured its milk from a farm where the milking is accomplished by the use of the milking machine. This Institute expressed its desire to have a comparative test of both methods made, the test to continue for the summer months, and offered every facility for carrying out the tests. The farm being under the constant supervision and immediate control of a Government dairy supervisor the circumstances were such as to render possible a complete comparative test of the two methods, the old and the new, working side by side, and under the very best conditions practicable.

Farm and Herd.

The following extracts from the report of the supervisor, Mr. McAdam, as presented to the Institute, furnish a full account of the milking herd and the management thereof:—

"The number of cows milked daily throughout the season averaged 95, chiefly of the Ayrshire type, all having undergone veterinary inspection and the tuberculin test at various times since 20th December, 1910. They were kept in good condition, well fed and groomed twice daily, stalled at nights, and during the day turned out into an area of about 20 acres, leased in connection with the farm as a run and exercise ground for the cows. The cows were brought up into the bails clean, and in a condition satisfactory for the supply of pure milk of the standard required by the Board of Management for the Institute."

Food Supply.

"The cows were fed mainly on fodder crops grown on the farm, with the addition of bran and a limited quantity of

brewer's grains, any food likely to be detrimental to the milk supply being guarded against, and no feeding allowed in the milking shed, but given to the cows immediately after milking."

Milking Methods.

"The milking has been done throughout the season with three L.K.G. milking machines. Before the machines were applied the milk of each cow was carefully examined by the supervisor, a small quantity being drawn from each teat for the purpose, as a check against milk being used from injured udders, and also as a means of detecting the symptoms of any of the various diseases of the udder affecting the milk supply. These precautions were taken daily throughout the season. The foremilk, about four streams from each teat, was then taken, and the teats and udders were carefully washed with warm water, clean water being used for each pair of cows. The machines were then applied, and after removal the cows were stripped out by hand into special buckets with cotton-wool strainers fitted into the mouth. The milk, after being weighed, was passed through a cleansing centrifuge, and thence over the refrigerator, and the temperature reduced to 40 deg. Fahr., and immediately bottled, sealed and dated, placed in crates, packed in ice, and delivered to the distributing agents within four hours after being milked, every precaution being taken during the whole process to ensure cleanliness. All utensils, milk bottles, and everything coming in contact with the milk was sterilised twice daily. All teat cups and rubberware in connection with the milking machines were boiled twice daily in soda water 10 per cent. strength, and left in the sterile water between milkings, and immediately before being used were blown out with dry steam. The machines were also sterilised at intervals during the milking operations by being placed in boiling water and soda after each machine had milked a pair of cows, opportunity being taken for this work in the interval during which the bails were hosed down and a fresh section of the herd brought in. The process of sterilising the milking machines received special attention by the supervisor through the season. All the employees at the dairy were provided with a clean

suit of overalls and cap for each milking, and received instructions from the supervisor throughout the season on sanitary methods in the production and handling of milk for infants, the same staff being employed right throughout the season."

Possible Sources of Bacterial Contamination.

Before describing in detail the results of the investigation it may be well to consider this subject.

It is well known that from many cows, provided that stringent precautions are taken, small quantities of absolutely sterile milk can be secured. Such extravagant precautions are, however, impossible in ordinary hand-milking conducted as a commercial undertaking. All that can be done is to minimise as far as possible the known sources of contamination. That much may be achieved in this direction is proved by the results not only of the examination of milk from the special cows reserved for this comparative test, but also by the results obtained by Dr. Bull in his examination of the general milk supply of the Lady Talbot Milk Institute. (See Report for 1911, p. 15.)

In hand-drawn milk the chief sources of contamination are:—

1. The milker's hands, and to some extent, his garments. In many cases there is no doubt that such are very important factors, especially where the method known as wet-milking is pursued.
2. The skin of the cow, particularly that covering the udder and teats. This is a common source of infection, for often no precautions are taken in regard to thorough washing of the udder and grooming of the flank, consequently scurf, etc., frequently enter the pail.
3. Atmospheric dust and manure particles falling into the bucket during and subsequent to the process of milking.
4. The milk in the teat duct. It is well known that the first milk invariably shows a much larger bacterial content than the average milk, due to invasion by

bacteria through the orifice of the teat duct between milkings.

In regard to the machine the chief sources of contamination are likely to be: —

1. The surface of the teat, which is being intermittently washed by the milk as withdrawn.
2. Air drawn into the cup at each pulsation through the small "air admission" aperture.
3. Bacteria within the teat duct.
4. Dirt within the apparatus itself.

It would seem therefore that the possible sources of infection are greater for the hand-drawn than for the machine-drawn milk, for the latter is but little exposed to contamination by the milker's hands, by the skin of the cow, or by dust and manure particles, as the receptacle is covered during the whole process of milking.

On the other hand if the mechanical apparatus be not thoroughly cleansed after use and small quantities of milk be allowed to remain in different parts between the times of milking, a suitable medium for the rapid multiplication of bacteria is provided, and a fertile source of danger is bound to be established.

In the investigation under review an endeavour was made to eliminate as far as practicable each and all of these sources of contamination in both the hand and the machine milking. For example, cleanliness in regard to the milker's hands and garments was insisted upon; washing the cow's udder and teats, and grooming the flanks with a damp brush was practised. The first ounce or two of the fore milk was withdrawn by hand and discarded, and in the case of the machine the apparatus was thoroughly sterilised, as can be seen by the supervisor's report already quoted; while the premises were kept in a thorough state of cleanliness.

For the purpose of the comparative test, four cows were selected, all being approximately of the same age, breed and condition, and each giving about the same quantity of milk. Two were carefully milked by hand and two by machine. Fair samples from the total supply of each pair were placed by Mr. McAdam, the supervisor, in sterile bottles, securely

stoppered and immediately cooled to about 40 deg. Fahr. These bottles, each containing a pint, were retained at a low temperature until delivery at the laboratory, where they were placed in an ice chest until tested.

The tests were conducted during January, February, March and April. During April, owing probably to the cooler weather, a marked general decrease in the bacterial content of both milks was experienced, the total number in each often falling below 250 per c.c. For this reason, the counts obtained in April have not been included in working out the averages given below.

On several occasions samples were delayed through various circumstances, so that they did not arrive at the laboratory until the second day after milking, and on other occasions, through error on the part of the agent, both samples were not received simultaneously, consequently certain days' records could not be included; but this does not interfere with the general results.

Throughout the test the appearance and palatableness of both milks were excellent, no taint or odour ever being detected, and the bottles on standing showed a good layer of cream. In regard to ordinary keeping qualities the milk, when kept in the ice chest at about 50 deg. Fahr., invariably remained perfectly sweet and wholesome for at least 48 hours after milking, even during the hottest summer months.

So far as the health of the cows, the condition of the udder and the quality of the milk, were concerned, throughout the whole period no difference whatever could be detected between those milked by hand and those milked by machine.

General Bacteriological Results.

Throughout the period under review the average number of bacteria present per cubic centimetre was in the hand-milk 7500, and in the machine-milk 6750. Naturally there was often a decided difference between the bacterial content of the two samples. For example, it was found that on 25 occasions the hand milk contained at least twice the number of bacteria present in the machine milk, while on 12 days the machine showed at least double the number found in the hand milk.

For the first six weeks the strippings of the two machine-milked cows were added to the bulk before the sample for examination was secured. Subsequently, however, this practice was discontinued, it being considered that such a method was really not fair either to the hand or the machine, as of course the strippings were removed by hand.

That the removal of the strippings by hand and their subsequent addition to the machine milk seemed to deteriorate the latter from the standpoint of bacterial purity is indicated by the following figures. During the period when this practice was adopted the hand milk showed 5000 bacteria per cubic centimetre, and the machine milk showed 10,750 bacteria as daily average, but during the following period when no strippings were added to the machine-drawn milk the average figures were 9500 for the hand, and but 3500 for the machine.

It must not be understood, however, that any definite and absolute conclusion can be drawn from these figures, for as a matter of fact, it will be seen that during the first half of the first period, the average tests were much more approximate than during the second half.

Bacteria Isolated.

For the first few weeks the nature of the different bacteria found present in the plates was carefully ascertained by sub-cultures on different media.

It was found that both the species and the relative number of each species varied so greatly that any results of scientific value could not be expected from pursuing this work further. In regard thereto, it is sufficient to state that in addition to the ordinary bacteria inducing lactic acid fermentation, *cocci* (particularly *staphylococci*) and *sarcinae* were common, while the *streptococcus* was conparatively rare. Various forms of saccharomyces were frequently encountered. The *colon* bacillus was not common, and the liquefying bacilli present were those found commonly in water.

A number of doubtful organisms were tested as to their pathogenicity for laboratory animals, but in no instance were the results fatal, and rarely was a passing inflammation produced.

Details of Examinations.

The appended tables show the results of each day's examination of the hand and machine-drawn milks.

Date 1611.	Hours before plating.	Hand. Temperature of Milk. °F.	Hand. Number of Bacteria per c.c.	Machine. Temperature of Milk. °F.	Machine. Number of Bacteria per c.c.
Jan. 3	13	59	4,000	59	3,750
4	10	66	6,000	67	5,750
5	9	75	3,000	76	10,000
6	27	66	5,250	66	3,250
7	9	71	4,500	71	5,000
9	27	71	4,500	75	10,500
10	9	73	10,750	73	3,750
11	9	64	2,000	64	3,750
12	8	64	3,000	65	2,750
19	8	59	4,250	59	4,000
21	28	57	3,500	57	2,250
23	8	69	3,250	73	2,750
26	10	74	1,500	74	1,250
27	8	70	2,250	69	4,000
28	27	60	3,500	60	2,000
30	18	60	2,000	60	1,750
31	18	60	1,500	60	7,250
Feb. 1	18	55	2,750	55	13,780
2	18	55	1,250	55	9,250
5	18	53	1,750	55	6,750
6	18	51	5,250	51	137,000
7	18	53	9000	54	1,500
8	18	51	12,000	50	33,750
9	18	50	3,500	59	8,500
10	18	49	11,250	47	1,000
12	18	51	24,000	51	11,500
13	18	47	3,800	46	7,250
14	18	51	9,000	51	1,500
15	18	51	6,750	55	10,750
17	18	51	1,250	50	2,500
20	18	60	58,500	59	3,500

Date 1911.	Hours before plating.	Hand Temperature of Milk. °F.	Hand Number of Bacteria per c.c.	Machine Temperature of Milk. °F.	Machine Number of Bacteria per c.c.
Fb. 21	18	55	3,500	55	1,000
22	18	55	6,500	71	4,000
23	18	55	15,250	59	5,000
24	18	49	7,000	51	3,500
26	18	49	2,500	51	3,250
27	18	55	7,000	55	1,000
28	18	54	9,000	53	15,500
Mch. 1	18	56	15,500	56	4,000
2	18	56	7,000	56	500
3	18	58	10,000	53	2,500
5	18	59	2,500	62	750
6	18	57	5,750	59	500
7	18	55	22,500	59	1,500
8	18	53	23,250	55	3,000
9	18	51	8,250	55	500
10	18	54	11,250	52	1,000
12	18	59	4,750	59	1,500
13	18	59	7,000	58	6,500
14	18	55	4,000	53	2,000
15	18	50	4,500	51	1,250
16	18	55	5,000	51	2,750
17	18	54	5,000	51	3,950
19	18	55	5,500	55	1,000
20	18	59	79,750	55	80,000
21	18	53	2,500	50	4,750
23	18	53	14,750	52	6,250
24	18	57	15,000	57	3,250
26	18	48	8,250	46	15,500
28	18	46	11,250	50	8,750
31	18	49	1,250	45	500
Apl. 2	18	58	5,000	59	750
3	18	67	1,000	65	250
4	18	56	250	57	1,250
5	18	52	500	55	5,000

Date 1911.	Hand. Hours before plating.	Hand. Temperature of Milk. °F.	Hand. Number of Bacteria per c.c.	Machine. Temperature of Milk. °F.	Machine. Number of Bacteria per c.c.
Apl. 6	18	52	*	53	*
7	18	53	500	56	26,000
9	18	51	*	49	1,250
10	18	50	*	51	6,000
11	18	49	250	49	*
12	18	47	250	47	2,250
17	18	56	*	57	*
18	18	52	*	52	*
19	18	50	*	50	*
20	18	44	5,600	44	*
21	18	46	5,750	47	250
24	18	50	1,800	49	1,250
25	18	48	1,400	49	2,400
26	18	52	2,250	52	1,000
27	18	52	4,500	52	500
28	18	52	6,000	52	3,250

Note.—* means less than 250 bacteria per c.c.

NOTES ON TABLES.

1. From January 3rd to January 28th the samples were taken from the morning milk.

2. From January 30th to April 28th the samples were taken from the evening milk.

3. From January 3rd to February 14th the machine milk was taken with the addition of the strippings drawn by hand.

4. From February 15th to April 28th the machine milk was taken without the addition of strippings.

5. From February 15th to March 20th the machines were used on test cows, immediately after removal from sterile solution.

6. From March 5th to April 28th the milk was delivered in ice chest as despatched from farm and without repacking.

7. From March 21st to April 28th the machines were used on test cows, after having previously milked 10 cows.

8. From April 9th to April 28th the cows were transposed as to method of milking.

On March 20th the excessive high count in both samples compared with previous and subsequent counts suggested that some unusual circumstances had been operating on the day in question. This view was confirmed by the fact that Dr. Bull's result from the same day's sample as sent to him from the ordinary supply was also unusually high. Careful inquiry led to the conclusion that on this particular day a certain batch of bottles had been ineffectively sterilised. In these circumstances that day's results have not been included in working out the average daily count of bacteria per c.c.

Results of Investigation.

The results of the above investigation have demonstrated the following points:—

1. That provided the apparatus of the milking machine is intelligently handled, and that it is thoroughly attended to as regards cleanliness and sterilisation, its use does not interfere with the general health of the cow or of the udder.
2. That the milking machine so used does not lead to a greater bacterial contamination of the milk than does the process of hand-milking, even when conducted under the most approved conditions, but that on the contrary the average results show an improvement.

In common with others, I have, however, noted in general practice that such pathological conditions as streptococcic mammitis, a common contagious disease of dairy cows, is much more readily spread by the milking machine than by the hand. As such a catastrophe can be readily obviated by a routine examination of each cow's udder prior to milking, a practice generally adopted by progressive dairymen, its occurrence should not be attributed to the machine alone, but to the carelessness or ignorance of its owner.

Given therefore the adoption of such precautions as are well within the compass of all dairymen, there appears to be no

reason for anticipating any danger to the milking industry through the extension of the employment of such apparatus as approved milking machines when employed with due regard to their cleanliness and sterilisation.

This investigation was conducted at the Veterinary Institute of the Melbourne University, and I desire to express my thanks to Professor Gilruth (in whose laboratory the work was carried out) for much valuable assistance and advice; to Mr. H. R. Seddon, for help in the examinations; to Mr. W. A. McAdam, who so carefully superintended the operations on the farm, and to the Lady Talbot Milk Institute for providing the necessary samples of milk.